

What is claimed is:

1. A system to process packets received over a network, the system comprising:

a receive process of at least one thread of a network processor, the receive process to receive data of packets, different ones of the packets belonging to different flows; and

a transmit process of at least one thread of the network processor to transmit packets received by the receive process;

a scheduler process of at least one thread of the network processor to populate at least one schedule of flow service based, at least in part, on quality of service characteristics associated with the different flows, the at least one schedule identifying different flow candidates for service; and

a shaper process of at least one thread of the network processor to select from the candidate flows for service from the at least one schedule.

2. The system of claim 1, wherein

the packets comprise Asynchronous Transfer Mode (ATM) cells;

the flows comprise at least one of virtual circuits and virtual paths; and

the quality of service characteristics comprise at least one of the following classes: Constant Bit Rate (CBR) and Variable Bit Rate (VBR).

3. The system of claim 1, wherein the system further comprises a queue manager process of at least one thread of the network processor to queue packets based on their associated flow.

4. The system of claim 3, wherein the queue manager is situated in a process-flow before the scheduler.

5. The system of claim 1, wherein at least one of the process threads communicates a message to a thread in a subsequent one of the processes via at least one neighbor register provided by a packet engine processing the at least one of the process threads.

6. The system of claim 1, wherein at least one thread of the scheduler process comprises more than one thread, different ones of the threads operating on different packet engines of the network processor.

7. The system of claim 1, wherein the at least one scheduler comprises a scheduler wheel having a collection of slots, an individual slot including an array of entries corresponding to different egress ports.

8. The system of claim 7, wherein individual entries within the array of entries comprise flow service candidates assigned to different service priorities.

9. The system of claim 7, wherein the at least one scheduler thread comprises at least one thread to cache at least one of the following in memory of a packet engine in the network processor: traffic parameters of a flow and a portion of a schedule wheel occupancy vector identifying scheduling candidate vacancies in the scheduling wheel.

10. The system of claim 7, wherein the at least one thread of the scheduler process comprises a thread to schedule service of a flow based, at least in part, on a port bandwidth vector associated with an egress port used to transmit packets, individual elements within the port bandwidth vector identifying whether a particular port has been reserved for transmission, individual elements within the port bandwidth vector corresponding to different slots within the at least one schedule wheel..

11. The system of claim 1, wherein the schedule comprises multiple schedule wheels, different wheels corresponding to different ports.

12. The system of claim 1, wherein
the at least one thread of the scheduler process comprises at least one thread to identify flows associated with best-effort service; and
the at least one thread of the shaper process comprises at least one thread to service a best-effort flow using egress port bandwidth unscheduled by the at least one schedule.

13. The system of claim 12, wherein the at least one thread to identify flows associated with best-effort service comprises at least one thread to send a message to at least one shaper thread identifying a subset of a best-effort vector, individual entries in the best-effort vector corresponding to a flow.

14. The system of claim 12,
wherein the at least one shaper thread identifies a schedule wheel slot processed by the shaper; and
wherein the at least one scheduler thread schedules a flow for service based on the identified schedule wheel slot.

15. The system of claim 12, wherein the at least one shaper thread processes each slot for the same amount of time.

16. The system of claim 1, wherein the at least one shaper thread:
queues flows associated with ports having flow control asserted; and
dequeues the flows after flow control is deasserted.

17. The system of claim 16, wherein
the shaper thread queues the flows with identification of classes of service associated with the flows and selects flows for servicing after flow control is deasserted based on the identification.

18. The system of claim 1, wherein the at least one of thread of the schedule process comprises a thread to schedule a flow for service in multiple slots.

19. A computer program product, disposed on a computer readable medium, the product including instructions for causing packet engines of a network processor to provide:

a receive process of at least one thread of a network processor, the receive process to receive data of packets, different ones of the packets belonging to different flows; and

a transmit process of at least one thread of the network processor to transmit packets received by the receive process;

a scheduler process of at least one thread of the network processor to populate at least one schedule of flow service based, at least in part, on quality of service characteristics associated with the different flows, the at least one schedule identifying different flow candidates for service; and

a shaper process of at least one thread of the network processor to select from the candidate flows for service based on the at least one schedule.

20. The product of claim 19, wherein

the packets comprise Asynchronous Transfer Mode (ATM) cells;

the flows comprise at least one of virtual circuits and virtual paths; and

the quality of service characteristics comprise at least one of the following categories: Constant Bit Rate (CBR) and Variable Bit Rate (VBR).

21. The product of claim 19, wherein the instructions further comprise a queue manager process of at least one thread of the network processor to queue packets based on their associated flow.

22. The product of claim 19, wherein at least one of the process threads communicates a message to a thread in a subsequent one of the processes via at least one neighbor register provided by a packet engine processing the at least one of the process threads.

23. The product of claim 19, wherein at least one thread of the scheduler process comprises more than one thread, different ones of the threads operating on different packet engines of the network processor.

24. The product of claim 19, wherein the schedule comprises a collection of slots, an individual slot including an array of entries corresponding to different egress ports.

25. The product of claim 24, wherein individual entries within the array of entries comprise flow service candidates assigned to different service priorities.

26. The product of claim 24, wherein the at least one thread of the scheduler process comprises a thread to schedule service of a flow based, at least in part, on a port bandwidth vector associated with an egress port, individual elements within the port bandwidth vector identifying whether a particular port has been reserved for transmission at a particular slot.

27. The product of claim 19, wherein

the at least one thread of the scheduler process comprises at least one thread to identify flows associated with best-effort service; and

the at least one thread of the shaper process comprises at least one thread to service a best-effort flow using egress port bandwidth unscheduled by the at least one schedule.

28. The product of claim 27, wherein the at least one thread to identify flows associated with best-effort service comprises at least one thread to send a message to a shaper thread identifying a subset of a best-effort vector, individual entries in the best-effort vector corresponding to a flow associated with best-effort service.

29. The product of claim 19, wherein the at least one scheduler thread comprises at least one thread to cache traffic parameters of a flow in packet engine memory.

30. A system to process Asynchronous Transfer Mode (ATM) cells received over a network, the system comprising:

- multiple line cards, an individual line card including:
 - at least one physical layer component (PHY); and
 - at least one network processor having multiple packet engines having access to instructions to provide:
 - a receive process of at least one thread of a network processor, the receive process to receive data of cells, different ones of the cells belonging to different virtual circuits; and
 - a transmit process of at least one thread of the network processor to transmit cells received by the receive process;
 - a scheduler process of at least one thread of the network processor to generate at least one schedule for virtual circuit service, based at least in part, on quality of service classes associated with the virtual circuits, the at least one schedule comprising a schedule wheel having a collection of slots, an individual slot including an array of entries corresponding to different ports, individual entries within the array of entries including virtual circuit service candidates assigned to different service priorities; and
 - a shaper process of at least one thread of the network processor to identify virtual circuits to service based on the schedule wheel slots; and

a switch fabric interconnecting the multiple line cards.

31. The system of claim 30, wherein at least one of the process threads communicates a message to a thread in a subsequent one of the processes via at least one neighbor register provided by a packet engine processing the at least one of the process threads.

32. The system of claim 30, wherein the at least one thread of the scheduler process comprises a thread to schedule service of a flow based, at least one part, on a port bandwidth vector associated with an egress port used to transmit packets for the flow, individual elements within the vector identifying whether a particular port has been reserved for transmission at a particular slot.

33. The system of claim 30, wherein
the at least one thread of the scheduler process comprises at least one thread to identify flows associated with best-effort service; and
the at least one thread of the shaper process comprises at least one thread to service a best-effort flow using egress port bandwidth unscheduled by the at least one schedule.

34. The system of claim 33, wherein the at least one thread to identify flows associated with best-effort service comprises at least one thread to send a message to a shaper thread identifying a subset of a best-effort vector, individual

entries in the best-effort vector corresponding to a flow associated with best-effort service.